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UK MILITARY REQUIREMENTS FOR ROBOTIC LAND VEHICLES

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This presentation describes the operational requirements and methods of achieving remote operation of Combat Engineer Equipments for use by the UK Army during periods immediately prior to combat, possibly during combat and extensively in battle area clearance operations. The techniques can also be used in peace support.

The paper examines the teleoperational requirements for the adaptation of existing Combat Engineer Vehicles such as the Chieftain Armoured Vehicle Royal Engineer (CH AVRE) also known as AVRE tank, and the Combat Engineer Tank (CET) and future requirements for service replacement vehicles such as Future Engineer Tank (FET) and Terrier (replacement CET).

The UK sponsor for this work is the Ministry of Defence, Main Building, Whitehall, London. I would like to thank Lieutenant Colonel Philip Poole, SO1 Engineer, DDOR (Engr&NBC) for assistance in offering advice and material on User requirements.

DERA Chertsey LS4 department is currently conducting applied research in support of the UK MOD programme for Combat Engineer Equipments and Robotic Land Vehicles.

INTRODUCTION

Unmanned ground vehicles have applications on the battlefield, for example in reconnaissance and mine clearance, where their use reduces danger to men. In this presentation, teleoperation and the technologies involved are discussed using examples of successful demonstrations. Current technology can already enable manned vehicles to be converted to remote operation for tasks where men would be particularly endangered. The introduction of unmanned ground vehicles (UGV) technology should therefore be evolutionary, with the aim of developing vehicles which have greater intelligence, independence and versatility, and which could save manpower at favourable costs.

The idea of robots on the battlefield will conjure up, to many, visions of large-walking creatures roaming free and destroying everything they encounter. Whilst the battlefield use of robots of such sophistication is still a long way off, UGV's of more limited capability are already making an important contribution to the modern army: UGVs are now widely used for explosive ordnance disposal (EOD) tasks, and have been used in this role for over 20 years.

Some advantages of using UGVs instead of manned vehicles are:

- Reduced risk to man (since destruction of an unmanned vehicle does not result in the loss of the driver and crew).
- The possibility of bolder concepts of operation, because of this reduced risk. Higher performance levels on extended and repetitive operations (where, for example, humans may suffer from fatigue, boredom or stress).
- Manpower reduction (as robotics compensate for a reduction in manpower without loss of effectiveness).

Conversely, disadvantages of the vehicles are:

- Their high cost.
- A lack of user confidence, acceptance and an increased logistic burden. UGVs are probably less flexible and adaptable than men.

User Requirements

Over the years, the need for, and scope of, Engineer support on the battlefield has been well established. It is provided by a wide variety of equipment and vehicles, optimised for their specific role and place on the battlefield. Engineers have, and will continue to use, a number of armoured vehicles to provide mobility, counter mobility and survivability support to formations whilst providing protection to their own crews. Combat Engineer Tractor (CET), Engineer tanks, the AFV 432 and CVR(T) all fulfil vital functions within Engineer regiments. It is planned to replace all of these vehicles in the next 10 years.

The current Chieftain Armoured Vehicle Launched Bridge (CHAVLB) and Chieftain Armoured Vehicle Royal Engineer (CHAVRE) were converted from Chieftain gun tanks in the 1970s and 1980s respectively, to replace their Centurion based predecessors. Experience gained on operations and in training and Operational Analysis have highlighted a major deficiency in the mobility of Chieftain Engineer variants when compared with the more agile armour that they support. This deficiency was exemplified on Op GRANBY (Gulf War) when Engineer vehicles fell behind between 3 and 6km, for every 10km advanced. The replacement of both vehicles will be carried out with Future Engineer Tanks (FET) having an in-service date of 2002/3 and the replacement of CET with the Terrier vehicle in 2006/7 will enable Engineers to provide improved close mobility support to armoured formations.

The mechanisms of Engineer Support, Engineer tasks on the battlefield involve mobility, counter mobility and survivability support. Tasks are undertaken throughout the width and depth of the area of operations, and are provided by a range of equipments with complementary characteristics and capabilities. Engineer mobility support tasks include wet and dry gap crossing, obstacle breaching, route opening, route maintenance, countermine and EOD battlefield clearance. Mobility is denied to an enemy through the enhancement of natural obstacles, the construction of man-made obstacles and the blocking of routes. The ability rapidly to construct earthworks and defences for all-arms protection is an essential part of survivability support.

It is the aim that the Robotic Land Vehicles research programme will help to enhance the Royal Engineers and other arms capability by improving mobility and counter mobility support to armoured formations.

Direction of UK RLV Programme

Two of the equipment types are discussed here where DERA have to date conducted research into teleoperation for remote driving and engineer tasks. Other applications for other Engineer vehicles will be likely in the future. The need for teleoperation techniques will most likely be in colour and contain elements of mono/stereo vision, augmented reality, virtual reality (VR) or a combination.

The programme has so far been concentrating on teleoperation kits for in-service vehicles such as the CHAVRE and the CET. It is seen as the most likely route for robotics to enter service and gain user acceptance. Acceptance of new technology equipments has always been a challenge to the researcher and the growing requirement these days is to show that the benefits to the user outweighs the cost of development.

We are currently investigating technologies that will improve teleoperation capabilities - these are stereo vision, optical flow, communications, image compression and augmented reality techniques.

Design Philosophy

The philosophy for the core area of the DERA research programme has been to take the latest available technology and assess its capabilities for the users requirement. Urgent operational requirements (UOR) occur from time to time. By assessing the latest technologies/equipments, rapid responses can be made when the need arises to provide appliqué kits for UORs.

The use of such kits allows flexibility where the kit can be removed reasonably quickly from the vehicle and it can then be interfaced with another type of vehicle. Commercial off the shelf equipment is used wherever possible. There must be no interference with the manual operation of the vehicle and a short change over time from manual to remote control by, for example switched operation. Design concepts must be space conscious as the controls and interface units must fit into already cramped spaces in the Engineer vehicles. Operator Control Units are required to be fitted into the secondary

vehicle. Space is an important consideration and the use of Helmet Mounted Displays or VR systems may help to alleviate this problem.

A recent injection of finance into the research budget has allowed the direction of the programme to investigate future teleoperation techniques such as novel vision and augmented reality for teleoperation.

Teleoperation Kit For Chieftain AVRE

Appliqué kits for possible UOR use in Bosnia and also as proof of principle for future FET and Terrier programmes were investigated in 1995/96. The system currently being used in the US SARGE programme was purchased and minor modifications were made to suit the UK MOD requirement. The AVRE mineplough and fascine operations were tested, using monovision teleoperation to drive the vehicle remotely and carry out the manipulative tasks. Other areas for consideration for teleoperation are, use by a single operator, selection of cameras and camera positions, the use of a microwave link for a line of sight video transmission from AVRE to the remote command vehicle.

Three cameras are fitted to the front of the vehicle and one at the rear. The centre front is mounted above the driver's head which improves forward vision by reducing obscuration by the ploughs. Two side cameras improve side/peripheral vision and allow accurate driving within narrow lanes or fenced off areas such as minefields. The rear camera allows accurate and fast reverse driving. Operator control units can be fitted to display single or multi image options.

Teleoperation Kit For Combat Engineer Tractor

Teleoperation for CET has been based on the methodology and hardware used on AVRE. From the AVRE trials, driving functions were not difficult, thus the CET research has been aimed at investigating and improving the manipulative tasks. Trials were conducted in spring 97. The main technical objective was to investigate digging tasks required in earth moving, the construction of obstacles such as sand banks and tank ditches. Clearance of obstacles was investigated, for example, filling in NATO standard tank ditches. Other clearance activities require the removal of heavy obstacles. For this, the CET 4-in-1 bucket is ideal for these manipulative type tasks, but not easy to implement because of limited visual perception. To carry out these tasks, camera positions and the numbers of cameras must be considered.

Operator Control Unit And Its Functions

The OCU unit was selected for its history of performance use on the US SARGE programme. In the UK research programme, it is used to perform driving and manipulative tasks. It can be purchased from Omnitech Robotics or Robotic Systems Technology and consists of a 486 33MHz PC with video LCD display and connections for interface outputs. Driving is via a motorbike handlebar control offering various functions such as steering, accelerator, braking and gear change. Control of the ploughing and fascine operations is done with the joystick.

Other functions have been modified to provide the 4-in-1 bucket controls. The bucket can be operated by joystick or by standard bulldozer lever type controls to provide such functions as raise/lower, digging/dumping, open/close and float/level grading.

The PC is able to offer many diagnostic capabilities - for our purposes items such as, gear status, vehicle speed, low oil pressure warning, safety status warnings, communication link dropout etc. have been incorporated.

Communications And Safety

Communications for remote links from the command vehicle to the remote vehicle offer control of the remote vehicle by two way radio link. The military vehicle radio, in the case of AVRE/CET is a VHF Clansman and was used to provide command functions, (e.g. engine start/stop, steering, accelerator and braking). Operation is at 4.8k baud rate and modulated into voice format. To prevent communication problems, two switchable antennas are used, one positioned 90degrees out of phase with the other antenna. This method of control is suitable with military radio links such as the UK's next generation Bowman system.

The tele-link is only required in one direction from the remote vehicle to the command vehicle to be able to carry out the visual driving and manipulative tasks. We have used a 1.3GHz FM commercial microwave link (Gigawave Antennas

UK) with circular polarised antenna for all round performance. The main problem is, this method generally requires line of sight communication to transmit the high bandwidth video image. Alternatively fibre optic links that offer high bandwidth can be used but the trailing of cables over 1-2km can be a problem in some scenarios.

Safety is paramount when remotely controlling the vehicles. The computer hardware has a safety unit with watchdog/command data safety flags. An in vehicle safety cut-off switch is also incorporated. This feature is essential when conducting evaluation trials, some of which do take place at the researcher's site. Some vehicles lose their hydraulic braking when the engine is switched-off, an important point to remember when considering safety. Software is required to be fail-safe but not safety critical.

Teleoperation Proving Trials

Trials were conducted in the UK to assess remote driving(1996) and engineer vehicle tasks (1997). Using colour monovision equipment, the MMI trials proved that driving was relatively easy but most other tasks varied in degrees of difficulty. Breaching ditches, grabbing and lifting was successfully achieved. With the 4-in-1 bucket, monovision highlighted perception problems during digging, such as loss of distance perception, depth and slope angle accuracy. The engineers became reasonably proficient within one day after using the equipment. Remote operations generally took up to 25% longer than when using the equipment manually.

ONGOING AND FUTURE WORK

Future topic to be covered are:

- Modelling for optimisation of operator perception and awareness, trials of stereo vision kit on the CET, assessment of head mounted displays and LCDs for stereo vision, use of inclinometers to judge slopes, the use of force feedback to "feel" driving and manipulation of the bucket, night driving - use of night vision equipment.
- Provision of increased user awareness, co-ordination with other nations and groups - US, France, SILVER (UK -DERA/Industry/Academia) and also keeping a watching brief on future potential technologies.

The core activity of our research for DDOR (Eng&NBC) continues to be improvements to in-service vehicles through current and future technologies such as VR. It is likely therefore that areas discussed in this workshop will feature in the future of remote control of Robotic Land Vehicles.

CONCLUDING NOTE

I believe that UGVs will become increasingly important for RLV tasks as they can be used on hazardous tasks without endangering men.

Reduced levels of manpower in the modern army need to be compensated for by increased levels of technology if the same or greater level of operational effectiveness is to be achieved. Repetitive and manpower-intensive tasks, such as conveying, logistic re-supply and security patrolling, could be carried out reliably by remote equipments and for longer periods, and would thus free people for other demanding tasks.

Bearing recent events from around the world in mind, it seems increasingly likely that the army of tomorrow will find itself involved more and more in operations other than war. Peacekeeping operations, with the intrinsic political unacceptability of loss of life, seem sure to promote the case for using teleoperated UGVs.